ARAC WG Report
Protection of fuel tanks in a minor crash landing
FAR/JAR 25.963(d), 25.721, and 25.994
June 12, 2000

Category 3

1 - What is underlying safety issue to be addressed by the FAR/JAR?

To protect fuel tanks from rupture during a minor crash landing.

2 - What are the current FAR and JAR standards relative to this subject?

Current FAR text:

§ 25.963(d) Fuel tanks within the fuselage contour must be able to resist rupture, and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in Sec. 25.561. In addition, these tanks must be in a protected position so that exposure of the tanks to scraping action with the ground is unlikely.

§ 25.721 General

(a) The main landing gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause--

(1) For airplanes that have a passenger seating configuration, excluding pilots seats, of nine seats or less, the spillage of enough fuel from any fuel system in the fuselage to constitute a fire hazard; and

(2) For airplanes that have a passenger seating configuration, excluding pilots seats, of 10 seats or more, the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.

(b) Each airplane that has a passenger seating configuration excluding pilot seats, of 10 or more must be designed so that with the airplane under control it can be landed on a paved runway with any one or more landing gear legs not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard.

(c) Compliance with the provisions of this section may be shown by analysis or tests, or both.

§ 25.994 Fuel system components.

Fuel system components in an engine nacelle or in the fuselage must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway.

Current JAR text:

JAR paragraph 25.963(e) is identical to FAR paragraph 25.963(d). JAR 25.963(d) reads as follows:

(d) Fuel tanks must, so far as it is practicable, be designed, located and installed so that no fuel is released in or near the fuselage or near the engines in quantities sufficient to start a serious fire in otherwise survivable crash conditions. (see also ACJ 25.963(d).

JAR paragraph 25.721 is identical to FAR § 25.721 and JAR 25.994 is identical to FAR 25.994.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

The JAA has an ACJ 25.963(d) to require additional items under a broad interpretation of JAR 25.963(d) and JAR 25.721. In addition Certification Review Items have been use to provide additional criteria.

The FAA has imposed fuel inertia loading condition on tailplane tanks outside the fuselage contour by use of a Special Condition:

Tailplane Tank Emergency Landing Loads. In addition to the requirements of § 25.963(d), the following applies;
(a) The tailplane tank in the horizontal stabilizer must be able to resist rupture and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in § 25.561.
(b) For the side load condition the quantity of fuel need not exceed 85 percent when determining pressure loads outside the fuselage contour for the 3g lateral direction.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?:

The main difference derives from JAR Paragraph 25.963(d) and the interpretations for 25.963(d) in ACJ 25.963(d).

ACJ 25.963(d) provides that the tanks outside the fuselage but inboard of the landing gear, or adjacent to the most outboard engine support the emergency landing loads of 25.561. All tanks outside the fuselage contour are assumed to be 85 percent full.

ACJ 25.963(d) also provides that fuel tank installations should be such that the tanks will not be ruptured by the airplane sliding with its landing gear retracted, nor an engine mounting tearing away.

4 - What, if any, are the differences in the current means of compliance?

ACJ 25.963(d) and a JAA Certification review items provide the means of compliance with 25.963(d) and also impacts 25.721 and 25.994. This includes fuel inertia loading for tanks outside the fuselage contour, considerations of sliding on the runway with combinations of landing gear not extended, additional landing gear breakaway criteria, and conditions of nacelles breaking away.

In compliance with the ACJ interpretation of JAR 25.963(d) the US manufacturers have used a chordwise head to determine fuel pressure under emergency landing load factors. The European manufacturers have used 85 percent of the maximum permissible volume

5 – What is the proposed action?

For each proposed change from the existing standard, answer the following questions:

6 – What should the harmonized standard be?

1. Amend Section 25.561 by revising paragraph 25.561 (c) to read as follows:

(c) For equipment, cargo in the passenger <u>and cargo</u> compartments, and any other large masses, the following apply:

(1) * * * * *

(2) When such positioning is not practical (e.g. fuselage mounted engines or auxiliary power units) each such item of mass shall be restrained under all loads up to those specified in paragraph (b)(3) of this section. The local attachments for these items should be designed to withstand 1.33 times the specified loads if these items are subject to severe wear and tear through frequent removal (e.g. quick change interior items). <u>Cargo in cargo compartments located below or forward of all occupants in the airplane need comply only with c(1)(ii).</u>

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2. Amend Section 25.721 to read as follows:

(a) The landing gear system must be designed so that when it fails due to overloads during take-off and landing the failure mode is not likely to cause spillage of enough fuel to constitute a fire hazard. The overloads must be assumed to act in the upward and aft directions - in combination with side loads acting inboard and outboard up to 20% of the vertical load or 20% of the drag load, whichever is greater.

(b) The airplane must be designed to avoid any rupture leading to the spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway, under the following minor crash landing conditions:

(1) Impact at 5 fps vertical velocity, with the airplane under control, at maximum design landing weight, all gears retracted and in any other combination of gear legs not extended.

(2) Sliding on the ground, all gears retracted up to a 20° yaw angle and as a separate condition, sliding with any other combination of gear legs not extended with 0° yaw

(c) For configurations where the engine nacelle is likely to come in contact with the ground, the engine pylon or an engine mounting must be designed so that when it fails due to overloads (assuming the overloads to act predominantly in the upward direction and separately predominantly in the aft direction), the failure mode is not likely to cause the spillage of enough fuel to constitute a fire hazard.

3. Amend Section 25.963 by revising paragraph 25.963(d) to read as follows:

(d) Fuel tanks must, so far as is practical, be designed, located, and installed so that no fuel is released, in quantities sufficient to start a serious fire, in otherwise survivable emergency landing conditions; and:

(1) Fuel tanks must be able to resist rupture and to retain fuel under ultimate hydrostatic design conditions in which the pressure P within the tank varies in accordance with the formula:

P=0.34*K*L

Where__

P = fuel pressure in psi at each point within the tank

L = a reference distance in feet between the point of pressure and the tank farthest boundary in the direction of loading..

K = 4.5 for the forward loading condition for fuel tanks outside the fuselage contour.

K = 9 for the forward loading condition for fuel tanks within the fuselage contour

K = 1.5 for the aft loading condition

K = 3.0 for the inboard and outboard loading conditions for fuel tanks within the fuselage contour

K = 1.5 for the inboard and outboard loading conditions for fuel tanks outside of the fuselage contour

K = 6 for the downward loading condition

K = 3 for the upward loading condition

(2) Fuel tank internal barriers and baffles may be considered as solid boundaries if shown to be effective in limiting fuel flow.

(3) For each fuel tank and surrounding airframe structure, the effects of crushing and scraping actions with the ground should not cause the spillage of enough fuel , or generate temperatures that would constitute a fire hazard under the conditions specified in §25.721(b).

(4) Fuel tank installations must be such that the tanks will not be ruptured by an engine pylon or engine mounting or landing gear, tearing away as specified in 25.721(a) and (c).

4. Amend Section 25.994 to read as follows:

Fuel system components in an engine nacelle or in the fuselage must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in § 25.721(b)

7 – How does this proposed standard address the underlying safety issue (identified under #1)?

- The proposed change to 25.561 would ensure fuel tanks would be protected from cargo shifting in the cargo compartment under emergency landing condition.
- The changes to 25.721(a) ensure that the conditions of landing gear tearing away are considered with reasonable level of side load condition, in addition to the upward and aft loads.
- The changes to 25.721(b) cover gear up combinations..
- The emergency landing load factors were established for solid mass items in the fuselage and bear little relevance to fluid in tanks especially external to the fuselage. Fuel pressure loads would be determined by an alternative set of factors rather than the emergency landing load factors which would achieve the same design level as already achieved in the operational fleet
- Certain pressure design factors (e.g. forward condition) for tanks outside the fuselage would be ½ of those on the inside of the fuselage. The calculated pressures would consider a full head rather than the chordwise head and all tanks would be considered full.

- A decent rate of 5 fps for the "minor crash landing" condition is established for the purpose of protecting fuel tanks.
- The conditions of landing with any gear combination not extended are clarified in 25.721 to require all gears retracted and any other combination of gear legs not extended.
- The conditions for landing gear breakaway in 25.721 are also clarified.
- Nacelle breakaway conditions are added to 25.721
- The minor crash landing condition is clarified for section 25.994 by referencing 25.721.
- Consideration of thermal effects is added to 25.963(d)

8 – Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

An increase in the level of safety because it adds fuel tank pressure load criteria to fuel tanks outside the fuselage contour, provides additional break-away criteria for nacelles, and a requirement to consider fuel tank heating.

9 – Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

Same or slight increase since much of the proposed criteria have been achieved by certification review items, equivalent safety findings, and for tail tanks, by Special Condition.

10 – What other options have been considered and why were they not selected?:

For the fuel tank pressure load criteria, the working group considered several options including a full pressure head criterion using the 25.561 load factors with a partially full tank (85 percent) and a chordwise head criterion with a full tank. Neither of these criteria was considered acceptable because they applied simplistic inertia load factors, derived for fixed mass objects in the fuselage, to a fluid outside the fuselage. In the end, it was decided to use fuel tank pressure factors for the tanks outside the fuselage that would achieve the current fleet strength levels for tanks outside the fuselage. The factors for tanks, inside the fuselage, were adjusted to ensure that they would not provide lower loads than the existing standards.

11 - Who would be affected by the proposed change?

The revised rule would be applicable to new airplanes for which the application for type certificate is received after the effective date.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?

Much of the proposed rule text is based on existing ACJ advisory material and certification review items. See the attached NPRM.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted?

There is no existing FAA advisory material, AC 25-963-2 and corresponding ACJ is proposed and is attached.

14 - How does the proposed standard compare to the current ICAO standard?

The current ICAO standard has no specific criteria for fuel tank protection.

15 - Does the proposed standard affect other HWG's?

No.

16 - What is the cost impact of complying with the proposed standard

Economic analysis still to be done but it is expected to be small in comparison to standard industry practice.

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

Advisory Circular AC 25.783-1A is submitted with full consensus of the working group

18.- -Does the HWG wish to answer any supplementary questions specific to this project?

Not at this time.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain.

Yes

Revised per Munch meeting 24 May 2000. Also revised 31 May 00. LCH removed change tracking. JH provided revised words for 25.561(c) and (c)(2) cargo in cargo compartments and re-orderd 25.721.

DRAFT– NOT FOR PUBLIC RELEASE. Dated 31 May 2000

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[14 CFR part 25]

[Docket No. ; Notice No.]

RIN:

Revised Requirements for the Structural Integrity of Fuel Tanks

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of proposed rulemaking.

SUMMARY: This notice proposes to revise the fuel tank design requirements of the Federal Aviation Regulations (FAR) for transport category airplanes to require that fuel tanks are designed for fuel pressures arising from emergency landing conditions. The proposals also include consideration of fuel tank ruptures due to the aircraft impacting on and subsequently sliding along the ground with all combinations of landing gears not extended and due to an engine pylon or engine mounting or landing gear tearing away. These actions would ensure that fuel tanks would be able to resist rupture and retain fuel under emergency landing conditions, thus increasing safety by reducing the risk of a post crash fire. This proposal has been developed in co-operation with the Joint Aviation Authorities (JAA) of Europe and the U.S., Canadian and European aviation industries through the Aviation Rulemaking Advisory Committee (ARAC).

DATES: Comments must be received on or before [insert a date 120 days after the date of publication in the Federal Register]

ADDRESSES: Comments on this notice may be mailed in triplicate to: Federal Aviation Administration (FAA), Office of the Chief Counsel, Attention: Rules Docket (AGC-10), Docket No. , 800 Independence Avenue SW., Washington, DC 20591; or delivered in triplicate to: Room 915G, 800 Independence Avenue SW., Washington, DC 20591. Comments delivered must be marked Docket No. . Comments may also be submitted electronically to nprmcmts@mail.hq.faa.gov. Comments may be examined in Room 915G weekdays, except Federal holidays, between 8:30 a.m. and 5:00 p.m. In addition, the FAA is maintaining an information docket of comments in the Transport Airplane Directorate (ANM-100), FAA, 1601 Lind Avenue SW., Renton, WA 98055-4056. Comments in the information docket may be examined weekdays, except Federal holidays, between 7:30 a.m. and 4:00 p.m.

FOR FURTHER INFORMATION CONTACT: James Haynes, Airframe and Propulsion Branch, ANM-112, Transport Airplane Directorate, Aircraft Certification Service, FAA, 1601 Lind Avenue, SW., Renton, WA 98055-4056; telephone (206) 227-2131.

SUPPLEMENTARY INFORMATION

Comments Invited

Interested persons are invited to participate in this proposed rulemaking by submitting such written data, views, or arguments as they may desire. Comments relating to any environmental, energy, or economic impact that might result from adopting the proposals contained in this notice are invited. Substantive comments should be accompanied by cost estimates. Commenters should identify the regulatory docket or notice number and submit comments in triplicate to the Rules Docket address above. All comments received on or before the closing date for comments will be considered by the Administrator before taking action on this proposed rulemaking. The proposals contained in this notice may be changed in light of comments received. All comments received will be available in the Rules Docket, both before and after the comment period closing date, for examination by interested persons. A report summarizing each substantive public contact with FAA personnel concerning this rulemaking will be filed in the docket. Persons wishing the FAA to acknowledge receipt of their comments must submit with those comments a self-addressed, stamped postcard on which the following statement is made: "Comments to Docket No. ____ ." The postcard will be date stamped and returned to the commenter.

Availability of NPRM

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the Fedworld electronic bulletin board service (telephone: 703-321-3339), the Federal Register's electronic bulletin board service (telephone: 202-512-1661), or the FAA's Aviation Rulemaking Advisory Committee Bulletin Board service (telephone: 202-267-5984).

Internet users may reach the FAA's web page at http://www.faa.gov or the Federal Register's web page at http://www.access.gpo/su_docs for access to recently published rulemaking documents.

Any person may obtain a copy of this notice by submitting a request to the Federal Aviation Administration, Office Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591; or by calling (202) 267-9680. Communications must identify the notice number of this NPRM. Persons interested in being placed on a mailing list for future rulemaking documents should also request a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, that describes the application procedures.

Background

The manufacturing, marketing and certification of transport airplanes is increasingly an international endeavor. In order for U. S. manufacturers to export transport airplanes to other countries the airplane must be designed to comply, not only with the U.S. airworthiness requirements for transport airplanes (14 CFR part 25), but also with the airworthiness requirements of the countries to which the airplane is to be exported.

The European countries have developed a common airworthiness code for transport airplanes that is administered by the Joint Aviation Authorities (JAA) of Europe. This code is the result of a European effort to harmonize the various airworthiness codes of the European countries and is called the Joint Aviation Requirements (JAR)-25. It was developed in a format similar to 14 CFR part 25. Many other countries have airworthiness codes that are aligned closely to 14 CFR part 25 or to JAR-25, or they use these codes directly for their own certification purposes. Since 1988, the FAA and JAA have been working toward complete harmonization of JAR-25 and 14 CFR part 25.

The Aviation Rulemaking Advisory Committee (ARAC) was established by the FAA on February 15, 1991, with the purpose of providing information, advice, and recommendations to be considered in rulemaking activities. The FAA and JAA are continuing to work toward the harmonization of JAR-25 and 14 CFR part 25 by assigning ARAC specific tasks. By notice in the Federal Register (59 FR 30081, March 15, 1993), the FAA assigned several tasks to an ARAC Working Group of industry and government structural loads specialists from Europe, the United States, and Canada. Task 1 of this charter included design requirements for the strength of fuel tanks. Subsequently, by notice in the Federal Register (63 FR 45895, August 27, 1998) the FAA chartered the same group of specialists with additional related aspects of fuel tank protection. Task 15 of this charter included the design and construction aspects of fuel tank protection from landing gear failures including wheels-up landing conditions (§§ 25.721 and 25.994). The assigned tasks were to review the current requirements for fuel tanks in 14 CFR part 25 and JAR-25 in order to define harmonized regulations that would be suitable for inclusion in both 14 CFR part 25 and JAR-25. The ARAC Loads and Dynamics Harmonization working group has completed its work for this task and has made recommendations to the FAA by letter dated ______________.

The existing § 25.963(d) includes a requirement to account for fuel inertia loads in the design of fuel tanks within the fuselage contour, and requires those tanks to be protected such that they are not exposed to scraping action with the ground. JAR-25 has the same requirement, but annotated as JAR 25.963(e). In addition JAR 25.963(d) specifies design requirements for all fuel tanks that, if ruptured, could release fuel in or near the fuselage or near the engines in quantities sufficient to start a serious fire. Section 25.721 contains conditions to protect fuel tanks from the effects of a landing gear breaking away and also to protect fuel tanks in a wheels-up landing. Section 25.994 contains a requirement to protect fuel systems and components in engine nacelles and the fuselage in a wheels-up landing on a paved runway. Although §§25.721 and 25.994 are identical in the JAR and FAR, there have been differences in interpretations and application of these requirements between and within the civil aviation authorities.

The current 14 CFR part 25 airworthiness standards § 25.963(d) prescribe conditions that the structure of fuel tanks located within the fuselage contour must be designed to withstand during an emergency landing. These conditions cover the resistance to the inertia forces prescribed by § 25.561 and protection such that exposure to scraping action with the ground is unlikely. However, the rule does not apply to other fuel tanks, such as wing fuel tanks, that are outside the fuselage contour. Adequate strength and protection against rupture for fuel tanks outside the fuselage contour has been achieved on existing airplanes by application of other design requirements.

For many years the British Civil Airworthiness Requirements (BCAR) have included a design condition that requires fuel tanks inboard of the landing gear or inboard of, or adjacent to, the most outboard engine to have the strength to withstand fuel inertia loads appropriate to the emergency landing conditions. The BCAR also addresses protection of fuel tanks against rupture by the airplane sliding with its landing gear disarranged and against engine mounts tearing away. In developing the common European airworthiness requirements, the Joint Aviation Authorities (JAA) also recognized that crashworthiness criteria for wing fuel tanks is necessary to ensure an adequate level of safety and since October 1988, the European Joint Aviation Requirements (JAR-25) have included a design requirement for fuel tanks outside of the fuselage contour, that now supersedes the previously cited BCAR requirement.

Service experience with respect to rupture of fuel tanks due to fuel inertia pressure loads is good. From this service experience, it is concluded that current airplanes should have adequate strength to meet this condition. However, this may not always be the case, especially if new airplane designs are significantly different from past conventional configurations in terms of length and breadth of the wing fuel tanks, or design and location of engines, or other sources of ignition. Without specific emergency landing conditions for fuel tanks outside of the fuselage contour, the current fuel tank crashworthiness requirements may not guarantee that adequate levels of fuel tank structural integrity will always be present.

Section 25.721 "Landing gear – general", contains two design requirements. The first requirement in paragraph 25.721(a) was adopted by amendment 25-23 (35 FR 5665, April 8, 1970) and provides for protection of fuel systems from a landing gear breaking away. This is considered a local component design criterion to protect fuel tanks from rupture and puncture due to the failure of the landing gear and its supports. This requirement applies only to fuel systems inside the fuselage for airplanes with 9 seats or less and to all fuel systems for airplanes with 10 seats or more. Experience has shown that the landing gear malfunctions can lead to landing on the engine nacelles for some configurations, and this can result in the engine nacelle breaking away, creating much the same fuel tank rupture potential as the landing gear breaking away.

Paragraph 25.721(b) provides for the protection of fuel systems in a wheels-up landing due to any combination of gear not-extended. This condition is not intended to treat a collapsed gear condition, but is intended to cover cases in which one or more gear do not extend for whatever reason and the airplane must make a controlled landing on a paved runway in this condition. This requirement only applies to airplanes with 10 seats or more. At the time this paragraph was adopted (amendment 25-32, 37 FR 3969, Feb 24, 1972), § 25.561 "Emergency landing conditions - General" contained a landing descent speed of 5 feet per second as an alternative criteria that could allow a reduction in the specified vertical emergency landing design load factor. This alternative was removed by amendment 25-64 (53 FR 17646, May 17, 1988) in order to make the specified vertical design load factor the minimum design condition. However, the 5 feet per second descent speed of § 25.561 had, by design practice and interpretation, become the design descent velocity for the wheels-up landing conditions of §§ 25.721 and 25.994. By removing it, the quantitative definition of the wheels-up landing condition on a paved runway was lost.

Section 25.994 was adopted by amendment 25-23 (35 FR 5665, April 8, 1970) and further revised by amendment 25-57 (49 FR 6848, Feb 23, 1984) to clarify that the wheels-up landing condition was on a paved runway. Advisory Circular 25.994-1 was also issued in July 24, 1986 which specifically referred to § 25.561 for the design conditions which at that time, contained the 5 feet per second landing descent criteria.

Discussion

Investigation of various types of accidents that result in high impact forces on the airframe shows that it is necessary to consider only three flight phases in which accidents could have a potential for occupant survival. These are final approach, landing and take-off.

In 1982, the National Aeronautics and Space Administration (NASA) completed a study, of commercial transport aircraft accidents. This study, reported in FAA Report No. DOT-FAA-CT-82-70, "Transport Aircraft Accident Dynamics" by A. Cominsky, records a total of 109 impact survivable accidents in the period between 1960-1980. The breakdown of these accidents is reproduced in Table 1. An impact survivable accident is defined by NASA as one in which there were fatalities, but not all occupants received fatal injuries as a result of impact forces imposed during the crash sequence. Since aircraft impact during approach is likely to be equivalent to the aircraft flying into the ground, FAA considers that this is too severe a condition to be the subject of design requirements. Nevertheless the figures for approach accidents are given in Table 1 for completeness.

TABLE 1

Injury Survey - Survivable Accidents

Period 1960 to 1980, Commercial Transport Aircraft

Accident Group	Number Of Accidents	Number of Passengers and Crew					
		Total	Injuries	Fatalities			
			Serious/ Minor/ None	Impact Trauma	Fire	Drowned	Unknown
Approach	27	2,113	1,078	434	298	15	288
Landing	33	3,058	2,637	157	227	23	14
Take-off	49	4,798	4,419	92	146	78	63
Total	109	9,969	8,134	683	671	116	365

A significant conclusion drawn from study of these accident statistics is that there are 50 percent more fatalities due to fire than to impact trauma in the survivable landing and take-off accidents. The FAA believes that it is proper, therefore, that post impact fire accidents merit attention in respect of airworthiness action aimed at protection of occupants.

In regard to § 25.963(d), ARAC has determined that the safety record with respect to fuel tank rupture due solely to fuel inertia loads is excellent. Manufacturers' records of accidents and serious incidents to large transport airplanes show no event where significant loss of fuel occurred due to fuel inertia pressure. Fuel losses that did occur were due mainly to direct impact and to puncturing by external objects.

Nevertheless, ARAC believes, and the FAA agrees, that a fuel inertia criterion for wing fuel tanks is still needed to ensure that future designs meet the same level of safety achieved by the current fleet. In setting an appropriate standard for this proposal, ARAC have reviewed the structural capability of the existing fleet. In that review it was shown that the outboard fuel tanks of a large part of the fleet could not be shown, theoretically, to be able to withstand the fuel inertia pressures generated by a wing full of fuel, combined with the emergency landing load factors of § 25.561(b)(3). In fact the wing fuel tanks of many aircraft types were designed to a simple criterion in which fuel pressure was calculated using an inertia head equal to the local geometrical streamwise distance between the fuel tank solid boundaries. Service experience has shown this criterion to produce fuel tank designs with an acceptable safety level. Therefore it is appropriate that the future airworthiness standards for fuel tanks should require a similar level of design fuel pressure for similar fuel tank designs.

For fuel tanks within the fuselage contour, the existing fuel inertia load criterion as generally applied covers up to a full fuel tank, an inertia head equal to maximum pressure head, and inertia load factors equal to those of § 25.561(b)(3). ARAC believes, and the FAA accepts, that this level of rupture resistance for fuel tanks is entirely justified based upon occupant survivability considerations. Any fire occurring due to spilled fuel inside the fuselage poses an almost immediate threat to the occupants. Therefore the current minimum level of rupture resistance is proposed to be retained for fuel tanks within the fuselage contour. In this regard, the design factors specified for the fuel tank pressure boundaries inside the fuselage are equivalent to those that would be developed with the emergency landing load factors of § 25.561(b)(3). The phrase "within the fuselage contour" in paragraph 25.963(d) has been subject to a variety of interpretations in the past. Fuel tanks "not within the fuselage contour" are all fuel tanks where fuel spillage through any tank boundary would remain physically and environmentally isolated from occupied compartments by a barrier that is at least fire resistant. In this regard, cargo compartments that share the same environment with occupied compartments would be treated the same as if they were occupied.

ARAC has determined, and the FAA concurs, that the fuel pressure requirement of § 25.963(d) should not reference the emergency landing load factors of § 25.561(b)(3). The rationale is that the emergency landing load factors of § 25.561(b)(3) are based upon the restraint of fixed mass items and the response of a fluid during emergency landings is different and much more complex to quantify. Therefore, the proposed requirements for fuel tanks both within and outside of the fuselage contour have been simply formulated in terms of equations with factors that are justified based upon the satisfactory service experience of the existing fleet.

Section 25.721 would be completely rewritten to include a wheels up landing condition, an engine nacelle breakaway condition, and a landing gear breakaway condition. The new proposed paragraph 25.721(b) defines the descent velocity, airplane configurations, and sliding conditions for a wheels-up landing on a paved runway. Paragraph 25.721(c) would prescribe a new requirement for consideration of the engine nacelle(s) breaking away if they are likely to come into contact with the ground in a wheels-up landing condition. The new proposed paragraph 25.721(a) would contain the landing gear breakaway condition which is similar to the existing landing gear breakaway condition except it would apply to all landing gear, not just the main gear, and it would apply to all transport airplanes without regard to seating capacity.

Section 25.994 would be revised to reference § 25.721(b) for the conditions that must be considered for the protection of fuel systems and components in engine nacelles and in the fuselage in a wheels-up landing on a paved runway.

Section 25.561(c) would be revised in order to provide a requirement to consider cargo in the cargo compartment. This revision would require that if cargo in the cargo compartment located below or forward of all occupants in the airplane were to break loose, it would be unlikely to penetrate fuel tanks or lines or cause fire or explosion hazards by damaging adjacent systems. The current requirement only addresses items of cargo in the passenger compartment.

The new proposed requirements for fuel tank protection would apply to all transport airplanes. ARAC has determined, and the FAA concurs, that there is no technical justification for limiting the applicability of any of the fuel tank protection provisions based on a passenger seating capacity.

Regulatory Evaluation Summary

<u>Preliminary Regulatory Evaluation, Initial Regulatory Flexibility Determination, and Trade Impact Assessment</u>

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) would generate benefits that justify its costs and is not a "significant regulatory action" as defined in the Executive Order; (2) is not significant as defined in DOT's Regulatory Policies and Procedures; (3) would not have a significant impact on a substantial number of small entities; and (4) would not constitute a barrier to international trade. These analyses, available in the docket, are summarized below.

Revised per Munch meeting 24 May 2000. Also revised 31 May 00. LCH removed change tracking. JH provided revised words for 25.561(c) and (c)(2) cargo in cargo compartments and re-orderd 25.721.

Regulatory Evaluation Summary

[To be completed]

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by Federal regulations. The RFA requires agencies to determine whether rules would have "a significant economic impact on a substantial number of small entities," and, in cases where they would, to conduct a regulatory flexibility analysis. " FAA Order 2100.1 4A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA requirements in FAA rulemaking actions. The Order defines "small entities" in terms of size thresholds, "significant economic impact" in terms of annualized cost thresholds, and "substantial number" as a number which is not less than eleven and which is more than one-third of the affected small entities.

The proposed rule would affect manufacturers of transport category airplanes produced under future new airplane type certifications. For airplane manufacturers, FAA Order 2100.14A specifies a size threshold for classification as a small entity as 75 or fewer employees. Since no 14 CFR part 25 airplane manufacturer has 75 or fewer employees, the proposed rule would not have a significant economic impact on a substantial number of small airplane manufacturers.

International Trade Impact Assessment

The proposed rule would have no adverse impact on trade opportunities for U.S. manufacturers selling airplanes in foreign markets and foreign manufacturers selling airplanes in the U.S. market. Instead, by harmonizing the standards of the 14 CFR part 25 and the JAR 25, it would lessen restraints on trade.

Federalism Implications

The regulations proposed herein would not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Thus, in accordance with Executive Order 12612, it is determined that this proposal does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

Because the proposed changes to the fuel tank crashworthiness requirements are not expected to result in any substantial economic costs, the FAA has determined that this proposed regulation would not be significant under Executive Order 12866. Because this is an issue that has not prompted a great deal of public concern, the FAA has determined that this action is not significant under DOT Regulatory Policies and Procedures (44 FR 11034; February 25, 1979). In addition, since there are no small entities affected by this rulemaking, the FAA certifies that the rule, if promulgated, would not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act, since none would be affected. A copy of the regulatory evaluation prepared for this project may be examined in the Rules Docket or obtained from the person identified under the caption "FOR FURTHER INFORMATION CONTACT."

List of Subjects in 14 CFR part 25

Air transportation, Aircraft, Aviation safety, Safety.

The Proposed Amendments

Accordingly, the Federal Aviation Administration (FAA) proposes to amend 14 CFR part 25 of the Federal Aviation Regulations (FAR) as follows:

PART 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for Part 25 continues to read as follows:

Authority: 49 U.S.C. app. 1347, 1348, 1354(a), 1357 (d)(2), 1372, 1421 through 1430, 1432, 1442, 1443, 1472, 1510, 1522, 1652(e), 1655(c), 1657(f), 49 U.S.C. 106(g)

2. To amend Section 25.561 by adding paragraph 25.561 (c) to read as follows:

(c) For equipment, cargo in the passenger <u>and cargo</u> compartments and any other large masses, the following apply:

(1) Except as provided in paragraph (c)(2) of this section, these items must be positioned so that if they break loose, they will be unlikely to:

(i) Cause direct injury to occupants;

(ii) Penetrate fuel tanks or lines or cause fire or explosion hazard by damage to adjacent systems; or

(iii) Nullify any of the escape facilities provided for use after an emergency landing.

(2) When such positioning is not practical (e.g. fuselage mounted engines or auxiliary power units) each such item of mass shall be restrained under all loads up to those specified in paragraph (b)(3) of this section. The local attachments for these items should be designed to withstand 1.33 times the specified loads if these items are subject to severe wear and tear through frequent removal (e.g. quick change interior items). <u>Cargo in cargo compartments located below or forward of all occupants in the airplane need comply only with c(1)(ii).</u>

* * * * *

* * * * *

3. To amend Section 25.721 to read as follows:

(a) The landing gear system must be designed so that when it fails due to overloads during take-off and landing the failure mode is not likely to cause spillage of enough fuel to constitute a fire hazard. The overloads must be assumed to act in the upward and aft directions - in combination with side loads acting inboard and outboard up to 20% of the vertical load or 20% of the drag load, whichever is greater.

(b) The airplane must be designed to avoid any rupture leading to the spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway, under the following minor crash landing conditions:

(1) Impact at 5 fps vertical velocity, with the airplane under control, at Maximum Design Landing Weight, all gears retracted and in any other combination of gear legs not extended.

(2) Sliding on the ground, all gears retracted up to a 20°yaw angle and as a separate condition, sliding with any other combination of gear legs not extended with 0° yaw.

(c) For configurations where the engine nacelle is likely to come in contact with the ground, the engine pylon or engine mounting must be designed so that when it fails due to overloads (assuming the overloads to act predominantly in the upward direction and separately predominantly in the aft direction), the failure mode is not likely to cause the spillage of enough fuel to constitute a fire hazard.

4. To amend Section 25.963 by revising paragraph 25.963(d) to read as follows:

(d) Fuel tanks must, so far as is practical, be designed, located, and installed so that no fuel is released, in quantities sufficient to start a serious fire, in otherwise survivable emergency landing conditions; and:

(1) Fuel tanks must be able to resist rupture and to retain fuel under ultimate hydrostatic design conditions in which the pressure P within the tank varies in accordance with the formula:

$$P=0.34*K*L$$

where:

P = fuel pressure in psi at each point within the tank

L = a reference distance in feet between the point of pressure and the tank farthest boundary in the direction of loading..

K = 4.5 for the forward loading condition for fuel tanks outside the fuselage contour.

K = 9 for the forward loading condition for fuel tanks within the fuselage contour

K = 1.5 for the aft loading condition

K = 3.0 for the inboard and outboard loading conditions for fuel tanks within the fuselage contour

K = 1.5 for the inboard and outboard loading conditions for fuel tanks outside of the fuselage contour

K = 6 for the downward loading condition

K = 3 for the upward loading condition

(2) Fuel tank internal barriers and baffles may be considered as solid boundaries if shown to be effective in limiting fuel flow.

(3) For each fuel tank and surrounding airframe structure, the effects of crushing and scraping actions with the ground should not cause the spillage of enough fuel, or generate temperatures that would constitute a fire hazard under the conditions specified in §25.721(b).

(4) Fuel tank installations must be such that the tanks will not be ruptured by an engine pylon or engine mounting or landing gear, tearing away as specified in 25.721(a) and (c).

5. To amend § 25.994 to read as follows:

Fuel system components in an engine nacelle or in the fuselage must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in § 25.721(b).

Issued in Washington D.C. on

Revised 24 May 00 in Munich. Change tracking removed by LCH 31 May 00. Changes also made to account for re-ordering of 25.721 in NPRM

DRAFT AC – NOT FOR PUBLIC RELEASE
Dated 31 May 2000.

U.S. Department
of Transportation
Federal Aviation
Administration

Advisory

Circular

FUEL TANK STRENGTH IN EMERGENCY LANDING CONDITIONS	Date: Initiated by: ANM-110	AC No. 25.963-2 Change:

1. PURPOSE. This advisory circular (AC) sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of part 25 of the Federal Aviation Regulations (FAR) related to the strength of fuel tanks in emergency landing conditions.

2. RELATED FAR SECTIONS. Part 25,

Section 25.561, "Emergency Landing Conditions", 25.721 "Landing Gear – General"

3. BACKGROUND. For many years the Federal Aviation Regulations have required fuel tanks within the fuselage contour to be designed to withstand the inertial load factors prescribed for the emergency landing conditions as specified in § 25.561. These load factors have been developed through many years of experience and are generally considered conservative design criteria applicable to objects of mass that could injure occupants if they came loose in a minor crash landing.

a. A minor crash landing is a complex dynamic condition with combined loading. However, in order to have simple and conservative design criteria, the emergency landing forces were established as conservative static ultimate load factors acting in each direction independently.

b. Recognizing that the emergency landing load factors were applicable to objects of mass that could cause injury to occupants and that the rupture of fuel tanks in the fuselage could also be a serious hazard to the occupants, § 4b.420 of the Civil Air Regulations (CAR) part 4b (the predecessor of FAR part 25) extended the emergency landing load conditions to fuel tanks that are located within the fuselage contour. Even though the emergency landing load factors were originally intended for solid items of mass, they were applied to the liquid fuel mass in order to develop hydrostatic pressure loads on the fuel tank structure. The application of the inertia forces as a static load criterion (using the full static head pressure) has been considered a conservative criterion for the typical fuel tank configuration within the fuselage contour. This conservatism has been warranted considering the hazard associated with fuel spillage.

c. The Joint Aviation Requirements (JAR) paragraph 25.963 has required that fuel tanks, both in and near the fuselage, resist rupture under survivable crash conditions. The advisory material associated with JAR 25.963 specifies design requirements for all fuel tanks that, if ruptured, could release fuel in or near the fuselage or near the engines in quantities sufficient to start a serious fire.

d. In complying with the JAR requirement for wing tanks, several different techniques have been used by manufacturers to develop the fuel tank pressure loads due to the emergency landing inertia forces. The real emergency landing is actually a dynamic transient condition during which the fuel must flow in a very short period of time to re-establish a new level surface normal to the inertial force. For many tanks such as large swept wing tanks, the effect is that the actual pressure forces are likely to be much less than that which would be calculated from a static pressure based on a steady state condition using the full geometric pressure head. Because the use of the full pressure head results in unrealistically high pressures and creates a severe design penalty for wing tanks in swept wings, some manufacturers have used the local streamwise head rather than the full head. Other manufacturers have used the full pressure head but with less than a full tank of fuel. These methods of deriving the pressures for wing tanks have been accepted as producing design pressures for wing tanks that would more closely represent actual emergency landing condition. The service record has shown no deficiency in strength for wing fuel tanks designed using these methods.

e. The FAR, prior to amendment 25-___, did not contain a requirement to apply fuel inertia pressure requirements to fuel tanks outside the fuselage contour, however, the FAA has published Special Conditions under FAR Part 21, § 21.16, to accomplish this for fuel tanks located in the tail surfaces. The need for Special Conditions was justified by the fact that these tanks are located in a rearward position from which fuel spillage could directly affect a large portion of the fuselage, possibly on both sides at the same time.

4. <u>GENERAL</u> FAR 25.963(d) as revised by amendment 25- __ requires that fuel tanks must be designed, located, and installed so that no fuel is released in quantities sufficient to start a serious fire in otherwise survivable emergency landing conditions. The prescribed set of design conditions to be considered is as follows:

a. <u>Fuel tank pressure loads</u>. FAR paragraph 25.963(d)(1) provides a conservative method for establishing the fuel tank ultimate emergency landing pressures. The phrase "fuel tanks outside the fuselage contour", with respect to this amendment, is intended to include all fuel tanks where fuel spillage through any tank boundary would remain physically and environmentally isolated from occupied compartments by a barrier that is at least fire resistant as defined in CFR 14, Part 1. In this regard, cargo compartments that share the same environment with occupied compartments would be treated the same as if they were occupied. The ultimate pressure criteria are different depending on whether the fuel tank under consideration is inside, or outside the fuselage contour. For the purposes of this paragraph a fuel tank should be considered inside the fuselage contour if it is inside the fuselage pressure shell. If part of the fuel tank pressure boundary also forms part of the fuselage pressure boundary then that part of the boundary should be considered as being within the fuselage contour. Figures 1 and 2 show examples of an underslung wing fuel tank and a fuel tank within a moveable tailplane, respectively, both of which would be considered as being entirely outside of the fuselage contour.

The equation for fuel tank pressure uses a factor L, based upon fuel tank geometry. Figure 3 shows examples of the way L is calculated for fuel pressures arising in the forward loading condition, while Figure 4 shows examples for fuel pressures arising in the outboard loading condition.

Any internal barriers to free flow of fuel may be considered as a solid pressure barrier provided:

(1) It can withstand the loads due to the expected fuel pressures arising in the conditions under consideration; and

(2) The time "T" for fuel to flow from the upstream side of the barrier to fill the cell downstream of the barrier is greater than 0.5 second. "T" may be conservatively estimated as,

$$T = \frac{V}{\sum_{i=1}^{j} C_{di} a_i \sqrt{2 g h_i K}}$$

where:

V is the volume of air in the fuel cell downstream of the barrier assuming a full tank at 1g flight conditions. For this purpose a fuel cell should be considered as the volume enclosed by solid barriers. In lieu of a more rational analysis, 2% of the downstream fuel volume should be assumed to be trapped air.

j is the total number of orifices in baffle rib

Cd_i is the discharge coefficient for orifice i. The discharge coefficient may be conservatively assumed to be equal to 1.0 or it may be rationally based upon the orifice size and shape

a_i is the area for orifice i

g is the acceleration due to gravity

h_i is the hydrostatic head of fuel upstream of orifice i, including all fuel volume enclosed by solid barriers

K is the pressure design factor for the condition under consideration.

b. Protection against crushing and scraping action.(Compliance with 25.963(d)(3) and 25.721(b) and (c)) Each fuel tank should be protected against the effects of crushing and scraping action (including thermal effects) of the fuel tank and surrounding airframe structure with the ground under the following minor crash landing conditions:

(i) An impact at 5 fps vertical velocity on a paved runway at maximum landing weight, with all landing gears retracted and in any other possible combination of gear legs not extended The unbalanced pitching and rolling moments due to the ground reactions are assumed to be reacted by inertia and by immediate pilot control action consistent with the aircraft under control until other structure strikes the ground. It should be shown that the loads generated by the primary and subsequent impacts are not of a sufficient level to rupture the tank. A reasonable attitude should be selected within the speed range from V_{L1} to 1.25 V_{L2} based upon the fuel tank arrangement.

(ii) Sliding on the ground starting from a speed equal to V_{L1} up to complete stoppage, all gears retracted up to a 20° yaw angle and as a separate condition, sliding with any other possible combination of gear legs not extended with a 0° yaw angle. The effects of runway profile need not be considered.

(iii) The impact and subsequent sliding phases may be treated as separate analyses or as one continuous analysis. Rational analyses that take into account the pitch response of the aircraft may be utilized, however care must be taken to assure that abrasion and heat transfer effects are not inappropriately reduced at critical ground contact locations.

(iv) For aircraft with wing mounted engines, if failure of engine mounts, or failure of the pylon or its attachments to the wing occurs during the impact or sliding phase, the subsequent effect on the integrity of the fuel tanks should be assessed. Trajectory analysis of the engine/pylon subsequent to the separation is not required.

(v) The above emergency landing conditions are specified at maximum landing weight, where the amount of fuel contained within the tanks may be sufficient to absorb the frictional energy (when the aircraft is sliding on the ground)without causing fuel ignition. When lower fuel states exist in the affected fuel tanks these conditions should also be considered in order to prevent fuel-vapor ignition.

c. Engine / Pylon separation. (Compliance with 25.721(c) and 25.963(d)(4))
For configurations where the nacelle is likely to come in contact with the ground, failure under overload should be considered. Consideration should be given to the separation of an engine nacelle (or nacelle + pylon) under predominantlyupward loads and under predominantly aft loads. The predominantly upward load and the predominantly aft load conditions should be analyzed separately.It should be shown that at engine/pylon failure that the fuel tank itself is not ruptured at or near the engine/pylon attachments.

d. Landing gear separation. (Compliance with 25.721(a) and 25.963(d)(4))
Failure of the landing gear under overload should be considered, assuming the overloads to act in any reasonable combination of vertical and drag loads, in combination with side loads acting both inboard and outboard up to 20% of the vertical load or 20% of

the drag load, whichever is greater. It should be shown that at the time of separation the fuel tank itself is not ruptured at or near the landing gear attachments. The assessment of secondary impacts of the airframe with the ground following landing gear separation is not required. If the subsequent trajectory of a separated landing gear would likely puncture an adjacent fuel tank, design precautions should be taken to minimize the risk of fuel leakage.

e. Compliance with the provisions of this paragraph may be shown by analysis or tests, or both.

5. RELATED FAR SECTION AND ADVISORY CIRCULAR

a. Supporting structure. In accordance with § 25.561(c) all large mass items that could break loose and cause direct injury to occupants must be restrained under all loads specified in § 25.561(b). To meet this requirement, the supporting structure for fuel tanks, should be able to withstand each of the emergency landing load conditions, as far as they act in the 'cabin occupant sensitive directions', acting statically and independently at the tank center of gravity as if it were a rigid body. Where an empennage includes a fuel tank, the empennage structure supporting the fuel tank should meet the restraint conditions applicable to large mass items in the forward direction.

b. Auxiliary fuel tanks. FAA Advisory Circular 25-8 "Auxiliary Fuel System Installations", provides additional information applicable to auxiliary fuel tanks carried within the fuselage. This AC 25.963-2 supersedes the emergency landing fuel pressure criteria from AC 25-8.

Revised 24 May 00 in Munich. Change tracking removed by LCH 31 May 00. Changes also made to account for re-ordering of 25.721 in NPRM

Figure 1: Diagram of Fuel Tank in Underslung Wing that is Outside of the Fire Resistant Boundary

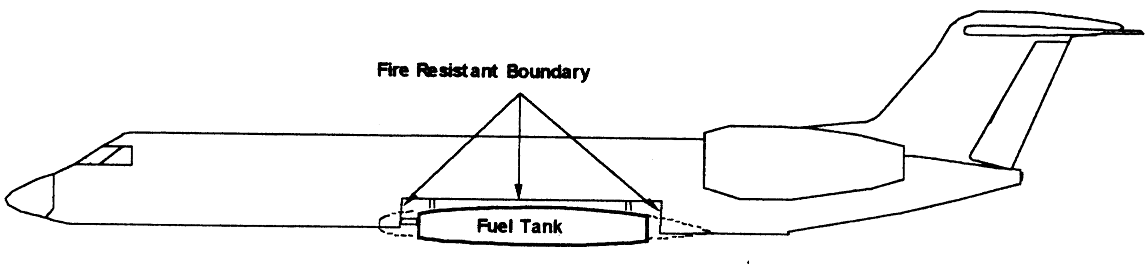


Figure 2: Diagram of Fuel Tank Within a Movable Tailplane

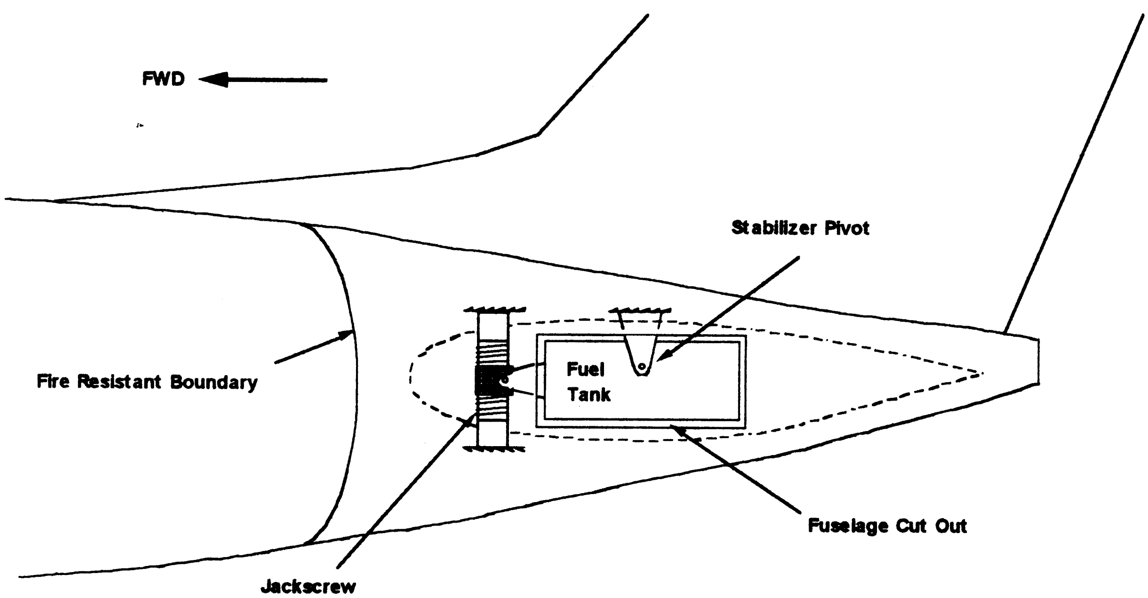
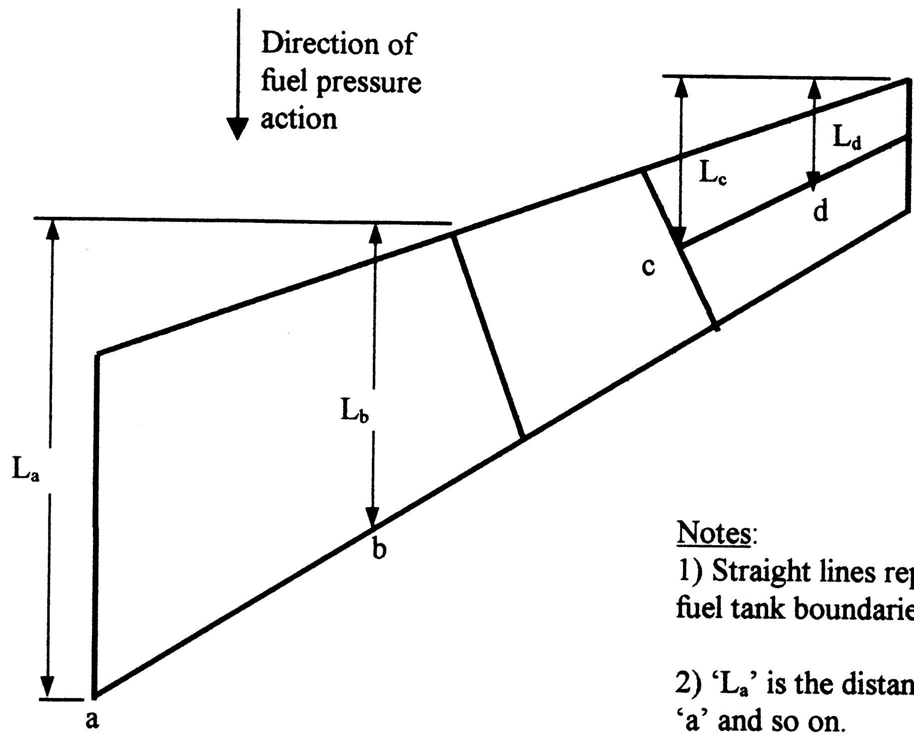


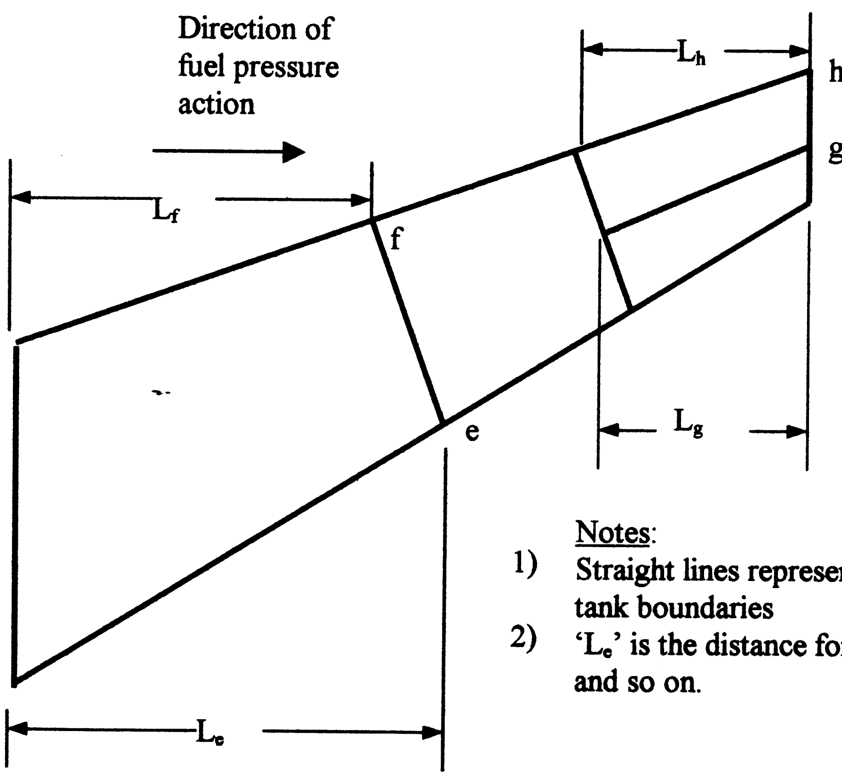
Figure 3- Example of Distances For Fuel Forward Acting Design Pressure Calculations



Notes:
1) Straight lines represent solid fuel tank boundaries.

2) ‘L_a’ is the distance for point ‘a’ and so on.

Figure 4 - Example of Distances For Fuel Outboard Acting Design Pressure Calculations



Notes:
1) Straight lines represent solid fuel tank boundaries
2) ‘L_e’ is the distance for point ‘e’ and so on.

Comments Received from L&D HWG as of 19 June 2000 on Fuel Tank Documents Submitted to TAEIG

Note: each member of the L&D HWG was provided the opportunity to comment on the WG report, NPRM and AC. Each was given 4 options:

A. I have no comments and I accept the document as written.
B. I object to the document going forward, for reasons given in the attached comments.
C. I can accept the document, but suggest improvements in the attached comments.
D. I do not fully agree with the document for reasons given in the attached comments, but I agree not to object to the proposal.

All responders selected A except for the following who had additional comments and thus selected "C" - I can accept the document, but suggest improvements in the attached comments. **The one exception is Boeing. They have selected "B" - I object to the document going forward, for reasons given in the attached comments.** Boeing comments are at the end of this document.

1. WG Report

a) Christian Beaufils – Airbus Industrie

PROPOSED WG report for 25.561,25.721,25.963 & 25.994

Airbus comments on draft dated 13 June 2000-06-16

The following improvements are proposed, as indicated in bold.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

The JAA has an ACJ 25.963(d) to require additional items under a broad interpretation of JAR 25.963(d) and JAR 25.721. In addition Certification Review Items have been use to provide additional criteria. **Recognizing that the local fuel head has been used in the past to justify crash capabilities of fuel tanks, JAA issued an interim policy in 1991 (INT/POL/25/9) allowing such an interpretation, in replacement of ACJ 25.963(d).**

The FAA has imposed fuel inertia loading condition on tailplane tanks outside the fuselage contour by use of a Special Condition:

<u>Tailplane Tank Emergency Landing Loads</u>. In addition to the requirements of § 25.963(d), the following applies;
(a) The tailplane tank in the horizontal stabilizer must be able to resist rupture and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in § 25.561.

(b) For the side load condition the quantity of fuel need not exceed 85 percent when determining pressure loads outside the fuselage contour for the 3g lateral direction.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?:

The main difference derives from JAR Paragraph 25.963(d) and the interpretations for 25.963(d) in ACJ 25.963(d) **and INT/POL/25/9**.

ACJ 25.963(d) **and INT/POL/25/9** provide that the tanks outside the fuselage but inboard of the landing gear, or adjacent to the most outboard engine support the support the emergency landing loads of 25.561. ~~**All tanks outside the fuselage contour are assumed to be 85 percent full.**~~

ACJ 25.963(d) **and INT/POL/25/9** also provide that fuel tank installations should be such that the tanks will not be ruptured by the airplane sliding with its landing gear retracted, nor an engine mounting tearing away.

4 - What, if any, are the differences in the current means of compliance?

ACJ 25.963(d), **INT/POL/25/9** and a JAA Certification review items provide the means of compliance with 25.963(d) and also impacts 25.721 and 25.994. This includes fuel inertia loading for tanks outside the fuselage contour, considerations of sliding on the runway with combinations of landing gear not extended, additional landing gear breakaway criteria, and conditions of nacelles breaking away.

In compliance with the ACJ interpretation of JAR 25.963(d), **prior issuance of INT/POL/25/9,** the US manufacturers have used a chordwise head to determine fuel pressure under emergency landing load factors. The European manufacturers have used 85 percent of the maximum permissible volume

7 – How does this proposed standard address the underlying safety issue (identified under #1)?

- The proposed change to 25.561 would ensure fuel tanks **and lines** would be protected from cargo shifting in the cargo compartment under emergency landing condition.

8 – Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

An increase in the level of safety because it adds fuel tank pressure load criteria to fuel tanks outside the fuselage contour, provides additional break-away criteria for nacelles, and a requirement to consider **a wheels-up landing condition including the** fuel tank heating **in case of fuel tank scraping action with the ground.**

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

Advisory Circular AC 25~~.783-1A~~ **963-2** is submitted with full consensus of the working group **(LCH note – this has been corrected in copy submitted to TAEIG)**

C.Beaufils. (Airbus)
16 June 2000

b) Jack Grabowski - Transport Canada

To: Larry Hanson/SAV/GAC@GAC
cc:

Subject: RE: Fuel Tank Sign -Off

Larry,
I will be signing all three sign-off sheets as C (with comments). My comments are in the nitpicking category - wording, typos etc.
I think that we should be careful with the phrases 'minor crash', 'wheels up' and where they are used since there are already existing definitions for the above and the additional uses implied may cause confusion. The comments below are placed under the three topics that we are signing for even though they may be repetitious.

Working Group Report.

Question 6 Item 2. Amend Section 25.721........

(b) The airplane must be designed to avoid any rupture leading to the spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway under the following minor crash landing conditions:

Question 6 Item 4. Amend Section 25.994........

Fuel system .... to constitute a fire hazard as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in 25.721(b).

Justification for removal: 25.721 specifies more than a simple 'wheels-up' condition

Question 7 Bullet 6.

A decent descent rate of 5 fps for the minor crash landing condition is established for the purposes of protecting fuel tanks in emergency landing conditions.

Question 7 Bullet 10.

The minor crash landing conditions is clarified for section 25.994 are clarified by referencing 25.721(b).

Question 17

Advisory Circular 25.783-1 addresses doors etc, Surely this is an incorrect reference. **(LCH Note: this has been corrected in the AC submittal to TAEIG)**

Question 20

The answer 'Yes' is ambiguous since there are two questions asked and no explanation provided.

2. NPRM

a) Christian Beaufils Airbus- Industrie

Proposed NPRM for 25.561,25.721,25.963 & 25.944

Airbus comments on draft dated 31 May 2000

The following improvement is proposed:

Add ' **unless the landing gear configuration is shown to be extremely improbable'** at end of sentences from 25.721(b)(1) and (b)(2).

Rationale:

The issue is about protection of fuel tanks against risk of fuel spillage which could lead to a fire hazard, in abnormal landing conditions where none or only some of the landing gear legs are extended.

The 5fps 'minor crash landing condition' prescribed in 25.721(b), with the proposed AC 25.963-2 interpretation, has been agreed by the LDHWH as one acceptable requirement condition to address this issue.

Airbus confirms agreement with this prescribed condition but emphasizes that this should be only ONE way, and we should not exclude for future a/c an alternative which would increase the level of safety compared with current standards. This alternative would be to design the landing gear systems so that all or some gear-up configurations would be extremely improbable, thus avoiding the landing gear configurations which could lead to risk of fuel spillage at landing.

This would lead to an increase of the a/c level of safety as instead of relying on a 'simplistic' 5fps minor crash condition, as proposed in 25.721(b), the landing gear configuration would be avoided.

Without such an alternative in the rule, there will be no incentive to promote such design improvement in the future.

C.Beaufils (Airbus)
16 June 2000

b) Jack Grabowski - Transport Canada

To: Larry Hanson/SAV/GAC@GAC
cc:

Subject: RE: Fuel Tank Sign -Off

Larry,
I will be signing all three sign-off sheets as C (with comments). My comments are in the nitpicking category - wording, typos etc.
I think that we should be careful with the phrases 'minor crash', 'wheels up' and where they are used since there are already existing definitions for the above and the additional uses implied may cause confusion. The comments below are placed under the three topics that we are signing for even though they may be repetitious.

Draft NPRM under Proposed Amendments.

3. To amend Section 25.721 to read as follows:

(b) The airplane .... as a result of a wheels-up landing on a paved runway under the following minor crash landing conditions:

(1) *********

(2) *********

(c) for configurations where .... so that when it fails failure occurs due to overloads ....

4. To amend Section 25.963 ......

(d)(4) Fuel tank installations ....or landing gear, tearing away separating as specified in 25.721(a) and (c).

5. To amend Section 25.994 to read as follows:

Fuel systems components ...... as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in 25.721(b).

3. AC

a) Christian Beaufils Airbus – Industrie

Proposed AC on 'Fuel Tank Strength in Emergency Landing Conditions'

Airbus comments on draft dated 31 May 2000

The following improvement is proposed.

§ 4(b) (I) and (ii)

Add ' **unless the landing gear configuration is shown to be extremely improbable'** within these paragraphs, in line with the proposed change for 25.721(b)(1) and (b)(2).

Rationale: see comments to NPRM

§ 4(b) (i)

It is better to keep the last sentence as agreed in Munich :

'Considering the fuel tank arrangement, a reasonable aircraft attitude and speed within the speed range from VL to 1.25 VL2 should be selected'.

§ 4(b)(iv)

It is not clear when the analysis should stop, in case of pylon/engine mounts failure. As the engine/pylon trajectory analysis is not required after engine/pylon separation, it seems illogical to go beyond this point in time.

Therefore, it is proposed to add the following sentence:
' The assessment of secondary impacts of the airframe with the ground following engine/pylon separation is not required.'

C.Beaufils (Airbus)
16 June 2000

b) Jack Grebowski - Transport Canada

To: Larry Hanson/SAV/GAC@GAC
cc:

Subject RE: Fuel Tank Sign -Off

Larry,
I will be signing all three sign-off sheets as C (with comments). My comments are in the nitpicking category - wording, typos etc.
I think that we should be careful with the phrases 'minor crash', 'wheels up' and where they are used since there are already existing definitions for the above and the additional uses implied may cause confusion. The comments below are placed under the three topics that we are signing for even though they may be repetitious.

Draft AC under Section 4 GENERAL.

(b) Protection against crushing ....
Each fuel tank should be protected ...... with the ground under the following minor crash landing conditions

(b)(iv) and (c) appear to cover the same general area although (c) refers to overload specifically. Therefore, use (b)(iv) for the situation where separation does not occur.

(iv) For aircraft with wing mounted engines, if failure of engine mounts, pylon or its attachments to the wing occurs without separation during the impact or sliding phases, the subsequent effect on the integrity of the fuel tanks in the associated wing structure should be assessed.

(c) Engine/Pylon Separation (Compliance with 25.721(c) and 25.963(d)(4).

For configurations where the nacelle/powerplant is likely to come in contact with the ground, failure under overload should be assessed. Consideration should be given to the separation of the engine nacelle (or nacelle + pylon) from its supporting structure under predominantly upward loads and predominantly aft loads acting separately. It should be shown that, at separation, the fuel tanks in that supporting structure are not ruptured at or near the engine/pylon attachments. Trajectory analysis of the engine/pylon subsequent to separation is not required.

c) Tony Linsdell – Bombardier Aerospace

To: Larry Hanson/SAV/GAC@GAC
cc: al064591@eng.canadair.ca

Subject: Fuel Tank Sign-off

Larry,

Comment on proposed AC 25.963-2
"FUEL TANK STRENGTH IN EMERGENCY LANDING CONDIOTIONS"

The AC is a very good document.

However the last sentence in para 4.b.(i) might lead to a variety of interpretations. I propose 1 additional sentence to help clarification.

In para 4.b.(i) I propose to add the following to the end of the paragraph,

" For example, a reasonable attitude would be as described in the wheels-up-landing procedure in the aircraft flight manual."

regards

Tony Linsdell
Bombardier Aerospace

d) Abe Jibril - Learjet

See suggested change in last sentence below:

b. Protection against crushing and scraping action.(Compliance with 25.963(d)(3) and 25.721(b) and (c)) Each fuel tank should be protected against the effects of crushing and scraping action (including thermal effects) of the fuel tank and surrounding airframe structure with the ground under the following minor crash landing conditions:

(i) An impact at 5 fps vertical velocity on a paved runway at maximum landing weight, with all landing gears retracted and in any other possible combination of gear legs not extended The unbalanced pitching and rolling moments due to the ground reactions are assumed to be reacted by inertia and by immediate pilot control action consistent with the aircraft under control until other structure strikes the ground. It should be shown that the loads generated by the primary and subsequent impacts are not of a sufficient level to rupture the tank. A ~~reasonable~~ normal landing attitude should be selected within the speed range from V_{L1} to 1.25 V_{L2}. ~~based upon the fuel tank arrangement.~~

4) General comments

a) Michael Lischke - DASA

DASA Comments on Fuel Tanks draft WG report, NPRM and AC
for 25.561, 25.721, 25.963, 25.944

From: Michael Lischke – DASA

To: Larry Hanson – Gulfstream

Larry,

of course the design of an airplane should avoid a fire hazard after a landing gear system failure as mentioned in 25.721.
The discussion about landing gear failures leads directly to the question of the probability of such a failure, as we discussed very intensively at the last WG meeting in Munich.
From my point of view this is in line with the 25.302 which talks about the probability of system failures in general.
Therefore the WG report, NPRM and AC should be limited to conditions **not extremely improbable.**

Michael Lischke
DASA
16.06.2000

b) Wim Doeland - JAA / RLD

To: Larry Hanson/SAV/GAC@GAC
cc: "'Andrew Goudie'" <andrew.goudie@srg.caa.co.uk>, "'Christophe Vuillot'" <vuillot_christophe@sfact.dgac.fr>

Subject: Submittals to TAEIG

Larry,

On Fuel Tank Crashworthiness (25.721/25.963) it's JAA position that we could accept the rules and advisory material as currently drafted by the L&DHWG. However, we also feel that the quality of the proposed advisory material (i.e. on the minor crash conditions to be considered) may benefit from further discussions by the L&DHWG.

Wim Doeland

c) Michael Green - Boeing

AVIATION RULEMAKING ADVISORY COMMITTEE

LOADS AND DYNAMICS HARMONIZATION WORKING GROUP

RECORD OF TECHNICAL CONSULTATION

Date 13 June 2000

PROPOSED NPRM FOR 25.561,25.721, 25.963, &25.944 Draft Dated: 31 May 2000

TITLE: **Revised Requirements for Structural Integrity of Fuel Tanks**

The referenced **NPRM** has been issued for consultation, and reviewed both at and subsequent to the Munich meeting.

In the opinion of the Chairman this document is ready for final acceptance.

As a member of the L&D HWG, please sign below, along with indicating the company that you represent plus a selection of a category from A through D below.

A. I have no comments and I accept the **NPRM** as written.
B. I object to the **NPRM** going forward, for reasons given in the attached comments.
C. I can accept the **NPRM**, but suggest improvements in the attached comments.
D. I do not fully agree with the **NPRM** for reasons given in the attached comments, but I agree not to object to the proposal.

Name	Signature	Company	Category A-D
Michael A. Green		Boeing	B (see attached comments)

AVIATION RULEMAKING ADVISORY COMMITTEE

LOADS AND DYNAMICS HARMONIZATION WORKING GROUP

RECORD OF TECHNICAL CONSULTATION
Date 13 June 2000

PROPOSED AC DATE OF DRAFT: 31 May 2000

AC NUMBER: 25.963-2

TITLE: **Fuel Tank Strength In Emergency Landing Conditions**

The referenced AC has been issued for consultation, and reviewed both at and subsequent to the Munich meeting. In the opinion of the Chairman this document is ready for final acceptance.

As a member of the L&D HWG, please sign below, along with indicating the company that you represent plus a selection of a category from A through D below.

A. I have no comments and I accept the AC as written.
B. I object to the AC going forward, for reasons given in the attached comments.
C. I can accept the AC, but suggest improvements in the attached comments.
D. I do not fully agree with the AC for reasons given in the attached comments, but I agree not to object to the proposal.

Name	Signature	Company	Category A-D
Michael A. Green		Boeing	B (see attached comments)

PROPOSED NPRM AND AC FOR 25.561,25.721, 25.963, &25.944 Draft Dated: 31 May 2000

Boeing Comments

The NPRM and AC being proposed are a more rigid interpretation of current requirements that do not recognize nor allow for the continuation of previous good design practices, and imply costly and extensive analyses in order to satisfy these requirements.

The proposed NPRM requires a wheels up landing analysis with a descent rate of 5 feet per second (fps). While we agree that requirements for protection of fuel tanks are necessary, the strict application of a 5-fps wheels up landing scenario may go beyond the intent of the proposed rule. It is clear that the proposed rule is not intended to address a safety problem in the existing fleet, but rather to clarify the existing requirements, eliminate the use of special conditions and certification review items, and maintain an existing level of safety for future designs. The current requirements for fuel tank protection do not specify a descent rate for the wheels up condition. Five feet per second has, in the past, appeared in paragraph 25.561(b)(3)(iv) as an alternate means of determining the downward minor crash landing load factors only (the 5 fps alternative was removed at Amendment 64). Five feet per second descent rate for wheels up landing has never been a specific requirement. The requirement for protection of fuel tanks during minor crash landings has been levied by Certification Review Items on Boeing airplanes, where the 5 fps descent rate has been specified as "an acceptable interpretation", not as the only means of compliance. The accepted means of compliance has been to maintain and demonstrate equivalent levels of safety by continuing with design features that have a proven safety record. The Boeing fleet, through extensive fleet history, has a proven design philosophy providing robustness between safe separation of nacelles and fuel tank protection for wheels up landing. The Boeing design philosophy does not specifically include an analysis at 5 fps descent speed, but instead includes a qualitative assessment of the design that ensures an equivalent level of safety with existing proven designs.

The proposed AC provides a means of compliance that implies detailed analyses of specific wheels up landing and sliding scenarios. While tools exist which may be used to simulate these complex scenarios, we are not confident in the design implications or the cost impacts of such analyses. There are no alternate means of compliance discussed which would allow for demonstration of good design practice based on extensive fleet history and proven design techniques.

Therefore, we feel that the proposals, without further investigation of analysis techniques and allowances for design practices, should not go forward at this time.